Brief information about the project

Name of the project	AP14870834 «Implementation of environmentally “clean” energy production technologies at Kazakhstan's TPP to reduce emissions of harmful substances into the atmosphere» (0122PK00588)
Relevance	Coal is being phased out in developed countries, but the industrial economy is still heavily dependent on fossil fuels. For developing countries, the impact on the environment remains a secondary factor, and traditional coal energy is successfully developing due to its cheapness. According to the Carbon Neutrality Strategy, Kazakhstan intends to abandon coal generation by 2060. Although the share of coal-fired plants will decrease in the future, coal will remain the main fuel of Kazakhstan's thermal power plants for the time being. Therefore, one of the urgent tasks of the domestic thermal power industry is the development of environmentally friendly “clean” coal technologies. The Project proposes to introduce a two-stage fuel combustion technology at the existing CHP plant, which makes it possible to control the processes of formation of harmful emissions and develop recommendations for their reduction.
Purpose	To implement the method of two-stage combustion of high-ash Kazakh coal using the latest information technologies and 3D computer modeling methods, investigate the processes of heat and mass transfer and the formation of harmful substances in the combustion chamber of the BKZ-75 boiler at Shakhtinskaya CHP and propose design solutions and optimal options for minimizing oxide emissions of carbon COx and nitrogen NOx.
Objectives	1) Determine the necessary technical and geometric parameters (dimensions of the combustion chamber and burner devices used, productivity, excess air ratio, number of burners and additional nozzles (injectors) and their height, method, volume and speed of supply of the aero mixture and additional air, fuel composition and oxidizer, etc.) and create geometric, physical, mathematical and chemical models that adequately reflect the real technological processes of combustion of domestic high-ash coal (Karaganda coal, ash content 35.1%) in the combustion chamber of the BKZ-75 boiler at Shakhtinskaya CHP. 2) Using modern information technologies (IT) in the thermal power industry and the experience of the project participants in the development of physical, mathematical and chemical models that describe the processes of heat and mass transfer in areas of real geometry (combustion chambers of power plants), create a package of computer programs for conducting computational experiments on the implementation of the method of two-stage combustion of high-ash coal in the combustion chamber of the BKZ-75 boiler at Shakhtinskaya CHP. 3) Conduct research to determine the impact of the introduction of the technology of two-stage combustion (two-stage combustion) of high-ash Karaganda coal on the characteristics of combustion processes: aerodynamics of flows, temperature fields, concentration fields of carbon CO_x and nitrogen NO_x oxides

	throughout the volume of the combustion chamber of the BKZ-75 boiler at Shakhtinskaya CHP and at the exit. 4) Using 3D computer modeling methods, explore various modes of supplying additional air to the combustion chamber through injectors, changing its volume from 0% (basic option, traditional combustion) to 30% of the total air volume required for fuel combustion, and indicate the best option for effectively reducing the level emissions of harmful substances such as carbon oxides CO_x and nitrogen oxides NO_x. 5) Use the developed package of computer programs for highly informative visualization of the obtained data for graphical interpretation of the research results: - two-dimensional graphs of changes in the height of the combustion chamber of the BKZ-75 boiler of the main characteristics of the process (speed, temperature, concentration of harmful substances); - 3D images of temperature and concentration fields in the characteristic sections of the furnace (the area of the burner belt and the installation of additional nozzles, the area of the longitudinal and cross sections of the combustion chamber and at the exit from it).. 6) Verify the results obtained by comparing them with the available experimental data obtained directly at the operating Shakhtinskaya CHP and theoretical calculations using the CKTI method [1]. 7) To propose effective design and layout solutions for the implementation of the technology of two-stage combustion of high-ash Karaganda coal in the combustion chamber of the BKZ-75 boiler and determine the optimal mode for supplying additional air through nozzles (injectors) to minimize the concentration of harmful substances at the outlet of the furnace space. The completed tasks will allow creating universal technologies and methods for studying the processes of fuel combustion and the formation of harmful dust and gas emissions at any thermal power plant and suggesting effective methods for burning low-grade coal in order to increase the efficiency of power plants and reduce the emission of harmful substances into the atmosphere.
Expected and achieved results	• Technical and geometric data will be determined to create geometric, physical-mathematical and chemical models that adequately reflect the actual technological processes of high-ash coal combustion in the furnace of the BKZ-75 boiler at Shakhtinskaya CHP. • A package of computer programs will be created for carrying out computational experiments to study the effect of two-stage combustion technology on the characteristics of combustion processes. • Various regimes for supplying additional air to the combustion chamber will be investigated, varying its volume from 0% (base case) to 30% of the total air volume required for fuel combustion, and the best option will be indicated to reduce carbon CO_x and nitrogen oxides NO_x.

	• A program for highly informative 3D visualization of the obtained results will be developed and their verification will be carried out by comparing them with experimental data obtained directly at the operating Shakhtinskaya CHP and theoretical calculations using the CKTI method. • Efficient design solutions will be proposed for the implementation of the technology of two-stage combustion of high-ash coal in the combustion chamber of the BKZ-75 boiler and the optimal mode for supplying additional air to minimize the concentration of harmful substances at the outlet of the furnace space will be determined. The results obtained will make it possible to effectively control the processes of fuel combustion in real power plants with the necessary impact on its various parameters, to find the best design solutions for burners, to create optimal methods for burning high-ash coal, to minimize harmful emissions into the atmosphere, which undoubtedly contributes to solving urgent problems of thermal power engineering and ecology. The results of the study are aimed at solving an urgent global problem - reducing emissions of harmful substances. The practical significance of the results is in obtaining new knowledge for constructing a modern theory of fuel combustion and its rational use. Other countries with traditional coal energy (Russia, China, India, Poland, Indonesia, Mongolia, Vietnam, etc.) will also be interested. The results of the research will be introduced into the educational process (bachelor's, master's, PhD) in the preparation of highly qualified, competitive specialists. The results of the research will be published in scientific publications indexed in the Web of Science and Scopus databases, which will determine the competitiveness of the team and scientific organization in which the Project is being implemented.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Bolegenova Saltanat Alihanovna, Doctor of Physical and Mathematical Sciences, Professor (h-index (Scopus) - 15, h-index (WoS) - 14, ResearcherID - A-9696-2015, ORCID - 0000-0001-5001-7773, Scopus Author ID – 57192917040). https://www.scopus.com/authid/detail.uri?authorId=57192917040 2. Askarova Aliya Sandybayevna, Doctor of Physical and Mathematical Sciences, Professor (h-index Scopus - 18, h-index Web of Science – 18, Researcher ID - N-6081-2014, ORCID - 0000-0003-1797-1463, Scopus Author ID – 6603209318). https://www.scopus.com/authid/detail.uri?authorId=6603209318 3. Maximov Valeriy Yurevich, Доктор философии (PhD) по специальности «Техническая физика» (h-index Scopus - 14, h-index Web of Science - 14, Researcher ID - F-6214-2013, ORCID - 0000-0003-4120-1071, Scopus Author ID – 57130389500). https://www.scopus.com/authid/detail.uri?authorId=57130389500 4. Beketayeva Meruyert Turganbekkyzy, PhD (h-index (Scopus) - 9, h-index (Web of Science) - 7, Researcher ID N-4828-2014, ORCID 0000-0002-0195-8304, Scopus Author ID -

	55901743200). https://www.scopus.com/authid/detail.uri?authorId=55901743200 5. Ospanova Shynar Sabitovna, PhD (h-index (Scopus) - 6, h-index (Web of Science) - 3, Researcher ID A-8880-2015, ORCID 0000-0001-6902-7154, Scopus Author ID - 55988678700). https://www.scopus.com/authid/detail.uri?authorId=55988678700 6. Nugymanova Aizhan, доктор философии PhD (h-index (Scopus) - 8, h-index (Web of Science) - 7, Researcher ID N-4527-2014, ORCID 0000-0003-0393-5672, Scopus Author ID - 57193723169).
List of publications with links to them	1. S. Bolegenova, A. Askarova, N. Slavinskaya, Sh. Ospanova, A. Maxuthanova Statistical modeling of spray formation, combustion, and evaporation of liquid fuel droplets // Physical Sciences and Technology. – Vol. 9, No. 3-4, 2022. – P. 69-82 (КОКСВОН); 2. С.А. Болегенова, А.С. Аскарова, Ш.С. Оспанова, А.М. Максутханова Жоғары турбуленттіліктегі гетерогенді жүйелердің технологиялық режимдерін оңтайландыру // Журнал проблем эволюции открытых систем. – Т.1, выпуск 24, 2022. – С. 55-65 (КОКСВОН). Кроме того, дополнительно, результаты исследований были апробированы на конференции Alternative energy sources, materials and technologies (AESMT'23): 1. A. S. Askarova, A. G. Georgiev, S. A. Bolegenova, V. Yu. Maximov, S. A. Bolegenova, A. O. Nugymanova, Adilbayev N. A. Staged supply of fuel and air to the combustion chamber to reduce emissions of harmful substances // Alternative energy sources, materials and technologies (AESMT'23); 2. A. S. Askarova, S. A. Bolegenova, Sh. S. Ospanova, S.A.Bolegenova, D. Yerbosynov, N. Ungarova. Direct numerical simulation of single-hole nonisothermal liquid jet injection // Alternative energy sources, materials and technologies (AESMT'23); 3. A. Askarova, S. Bolegenova, A. Georgiev, M. Beketayeva, S. Bolegenova, V. Maximov, N. Adilbayev. Selection of the optimal kinetic scheme for the formation of nitrogenous substances in the simulation of low-quality coal combustion in the furnace chamber of a real heat-power facility // Alternative energy sources, materials and technologies (AESMT'23).
Patents	-